RUBBER TIRE RETAINING WALL

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2001

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by
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A dissertation submitted
in partial fulfillment of the requirements for the
degree of Bachelor of Engineering (Hons)
in Civil Engineering

Faculty of Engineering
UNIVERSITI MALAYSIA SARAWAK
April 2001

BORANG PENYERAHAN TESIS

Judul: RUBBER TIRE RETAINING WALL

SESI PENGAJIAN: 2001

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Dedicated to my beloved parent

and

thesis students

ACKNOWLEDGEMENTS

A grateful acknowledgement to the contribution of the peoples that enable me to complete my thesis paper. I would like to thank my supervisor, Cik Siti Noor Linda for the helpful comments and useful guidance.

I also like to express my gratitude to my family and friends for their help, support and encouragement.

ABSTRAK

Semakin banyak kejadian tanah runtuh berlaku di Malaysia. Fenomena ini biasanya berlaku di kawasan tebing bukit disebabkan oleh ketidakstabilan struktur tanah. Ia bukan sahaja memusnahkan keindahan alam, malah boleh mengancam nyawa manusia yang menduduki berhampiran dengan kejadian di mana tanah runtuh berlaku.

Pelbagai usaha telah dilaksanakan bagi mengatasi masalah ini. Antaranya ialah pembinaan tembok penahan di sepanjang tebing bukit yang diketahui kelemahan struktur tanahnya. Tembok penahan konkrit ialah struktur yang paling lumrah dipergunakan. Keberkesanannya terhadap penahanan kejadian tanah runtuh tidak dapat dinafikan. Namun begitu, kos pembinaannya terlalu tinggi.

Dengan adanya tembok penahan menggunakan tayar lama ini, ia dapat mengurangkan kos pembinaan. Struktur ini bukan sahaja dapat mengukuhkan kestabilan tanah, malah dapat mengatasi pencemaran udara (jika tayar lama dibakar) dengan penggunaan semula tayar lama. Penyemakan kestabilan tembok penahan tayar ini adalah berdasarkan kepada penyemakan yang dijalankan pada tembok penahan konkrit.

ABSTRACT

More landslides occur in Malaysia nowadays. This phenomenon frequently occurs at hillsides when the structure of the soil is unstable. Landslide not only damages the beauty of Mother Nature, it also threatens the life of those who stay nearby.

Several efforts have been taken to overcome the problem caused by landslide. The most general method is to build a concrete retaining wall along the hillside where the structure of soil is weak. Its effectiveness to retain the slope is very efficient. Nevertheless, the cost of construction is very expensive.

Rubber tire retaining wall is a new method to be used in order to reduce the construction cost. It not only strengthens the stability of the slope, but also solves the problem of air pollution (if rubber tires were burnt) by recycling the old rubber tires. The stability of a rubber tire retaining wall is checked based on the method of concrete retaining wall.

CONTENTS

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CHAPTER 1

An economical structure of retaining wall needs to be carried out to take over conventional methods. This chapter explains the objectives of the thesis. It also briefly describe the advantages of **rubber tire retaining wall** compare to conventional structures.

Introduction

1.1 General

In Malaysia, landslide frequently occurs. This phenomenon can happen anywhere especially on road that is built along a hill site or buildings that are built at the peak of hill.

Generally, landslide will happen during heavy rainy season. Rain become an agent of erosion and will weaken the structure of particle soil. Consequently, particle soil become loosen and causing slope to be unstable.

To prevent landslide, it is required that a strong structure to be built to retain the soil, which have potential to slide. The structure that is to be built needs a thorough research and must be careful during design. The economical of the structure and environment impact also need to be considered. The engineer will try to cut down the cost but with most effective way to design a suitable structure to prevent landslide from occurring.

1.2 Objectives

Recently, landslide can be prevented by building a concrete retaining wall along a hill site that has potential to fall. This concrete wall seems to be very effective to protect the slope, but the problem of the concrete retaining wall is its cost which is too expensive and its being time consuming either during design or during construction. As a result, a country that is frequently having potential landslide is looking other alternatives to stop this disaster. Some of them used geotextile, box wall, gabion walls, nailed wall and many more, nevertheless the cost of construction is still high.

Therefore, since 1969, through research and development, there is a new idea of developing retaining wall with a minimum cost but have same effectiveness with concrete retaining wall to prevent landslide. This method is called **rubber tire retaining wall**.

This type of wall can be easily built by unskilled labour. It can be built within a few days using simple tools. One of the advantages of rubber tire retaining wall is it can effectively prevent landslide. They are very different from conventional retaining walls in that they are integral with the earth they are retaining. Conventional retaining walls of masonry can crack due to pressure build up from moisture behind the wall as well as freeze or thaw of that moisture. These cracks can lead to structural failure. On the other hand, Earthrammed tire walls are made of earth itself packed to 90% compaction and encased in steel belted rubber tires. A crack is not possible in this condition of earth and rubber.

CHAPTER 2

Soil stability plays an important role in determining whether a structure is required to prevent landslide from occurring. Numerous forces that cause land movements will be described in this chapter.

Soil Stability

2.1 When Slope Not Stable?

Slope stability is based on the interplay between two types of forces, driving forces and resisting forces. Driving forces promote downslope movement of material, whereas resisting forces deter movement. So, when driving forces overcome resisting forces, the slope is unstable and results in mass wasting.

2.1.1 Driving Forces

The main driving force in most land movements is gravity. The main resisting force is the material's shear strength. Slope angle, climate, slope material and water contributes to the effect of gravity. Mass movement occurs much more frequently on steep slopes than on shallow slopes.

Water plays a key role in producing slope failure. In the form of rivers and wave action, water erodes the base of slopes, **removing support**, which **increases driving forces**. Water can also increase the driving force by **loading**. An increase in water also contributes to driving forces that result in slope failure. The weight (load) on the slope increases when water fills previously empty pore spaces and fractures. The shear strength of the slope material is decreased due to the increasing of pore water pressure.

2.1.2 Resisting Force

Resisting forces act oppositely of driving forces. The resistance to downslope movement is dependent on the **shear strength** of the slope material. And shear strength is a function of **cohesion** (ability of particles to attract and hold each other together) and **internal friction** (friction between grains within a material).

Water can contribute to resisting forces when sediment pores are partially filled with water. The thin film of water acts as a binder, making the particles cohesive.

2.2 The Ratio of Resisting Forces To Driving Forces

The ratio of resisting forces to driving forces is the safety factor (SF):

SF= Resisting forces/driving forces

If SF > 1 then *safe*

If SF < 1 then *unsafe*

From the equation above, the slope can be checked whether it needs a structure to retain the soil mass from sliding. For designing, the ratio of resisting forces to driving forces is normally 1.5.

2.3 Factors of Slope Stability

Slope stability is therefore a function of material, strength of rock or soil, slope angle, climate, vegetation, and time. Each of these factors may play a significant role in controlling driving or resisting forces.

How does slope angle affect both driving and resisting forces? Given that the total weight (W) of a mass that resists on a potential failure surface. *Slope angle*, **A** can be divided into two components, **N** and **D** for a given **W**, **N** and **D** change dramatically with change in the slope angle **A** whereby **W**, **N** and **D** are as below:-

W = The weight of component caused by gravity force.

N = The vectoral component of weight that acts normal to the failure surface. Increase in **N**, increases the frictional component, thereby increasing the resisting forces.

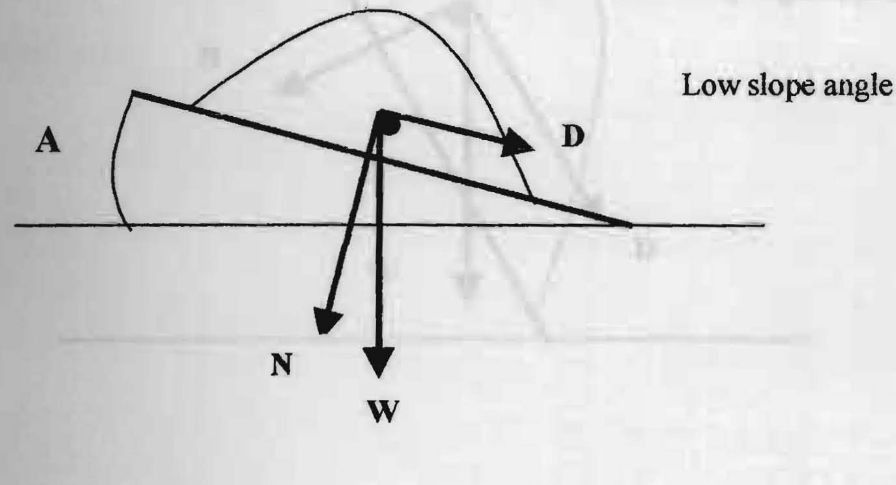
D = The vectoral component of weight that acts in the direction of failure.

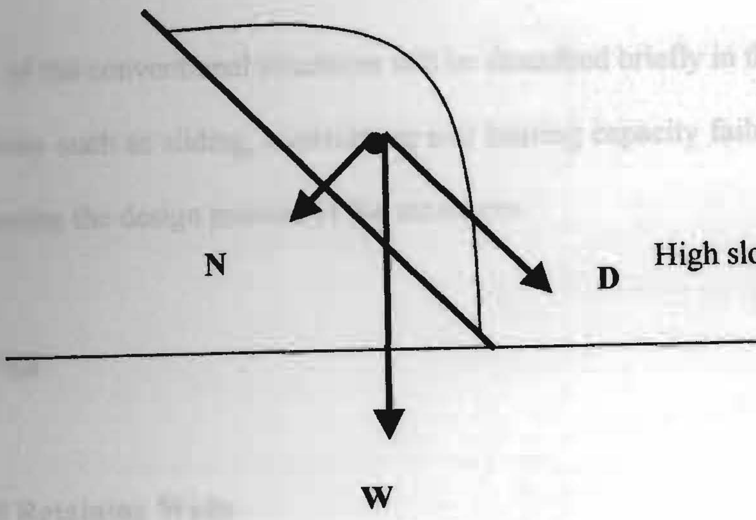
W cos A = N

W sin A = D

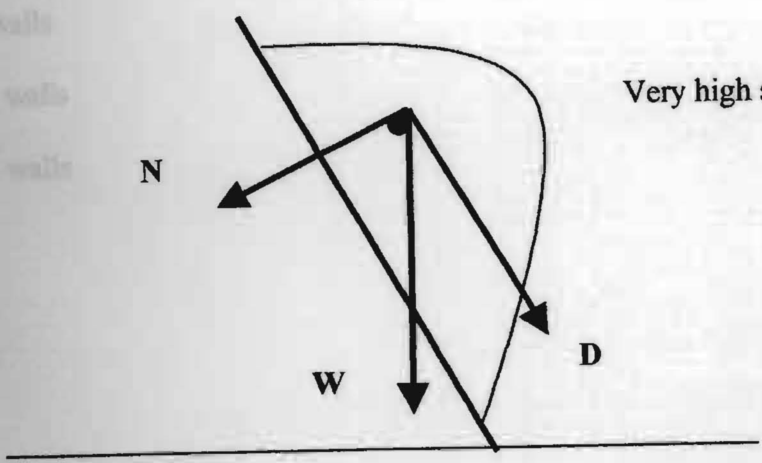
The affect of slope angle to both driving and resisting forces shown in **Figure 2.3.1.**

Figure 2.3.1 **Slope angle affect both driving and resisting force**





High slope angle



Very high slope angle

CHAPTER 3

Some of the conventional structures will be described briefly in this chapter. External stability such as sliding, overturning and bearing capacity failure need to be checked during the design process of the structures.

Retaining Wall

3.1 Types Of Retaining Walls

In general, there are a few types of traditional retaining walls.

- Foundation walls
- Gravity walls
- Cantilever walls
- Counterfort walls
- Butteressed walls

3.1.1 Foundation Walls

Foundation walls are basement walls of buildings. The additional floor slabs and floor joists typically support these walls shown in **Figure 3.1.1a**.

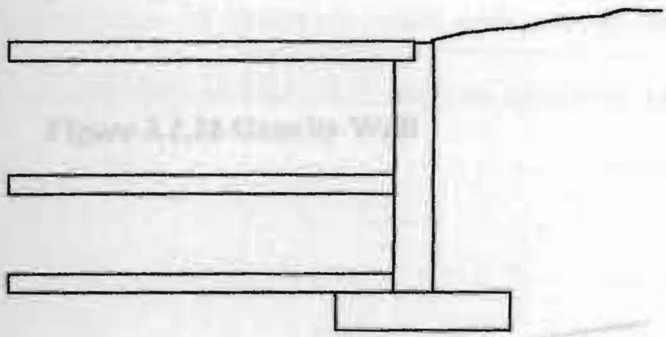
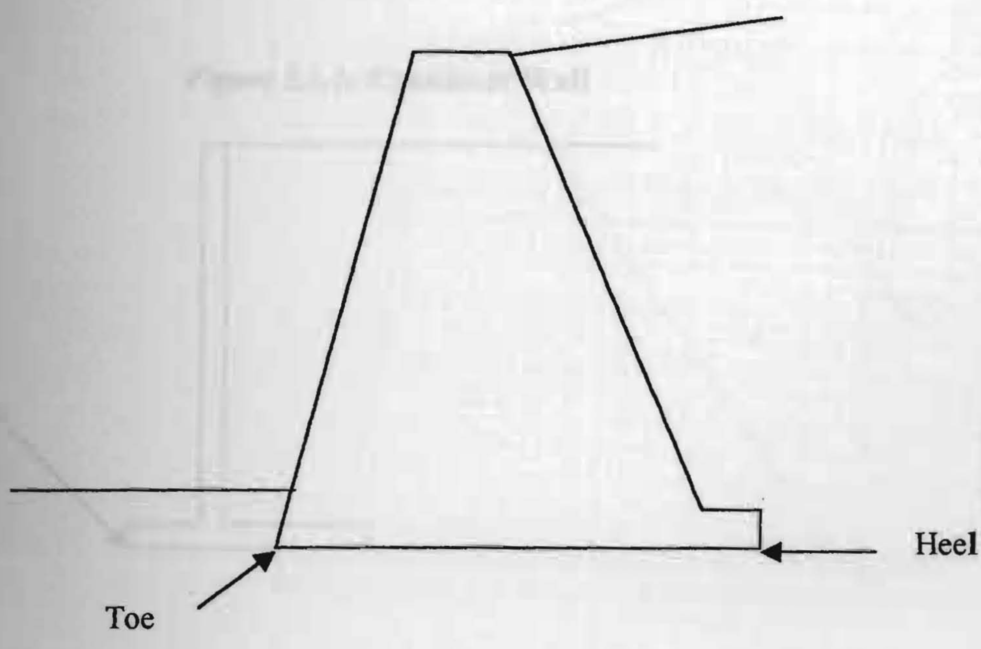


Figure 3.1.1a **Foundation Wall**

3.1.2 Gravity Walls

Gravity walls are massive walls that rely on their trapezoidal shape and treat weight to minimize tensile stresses in the concrete. No reinforcing steel is used. These walls have been constructed as high as 130 ft. However, they are used mainly for low walls. The base width is typically 0.4 to 0.7 of the wall height H. **Figure 3.1.1b** shown the typical of *gravity wall.*

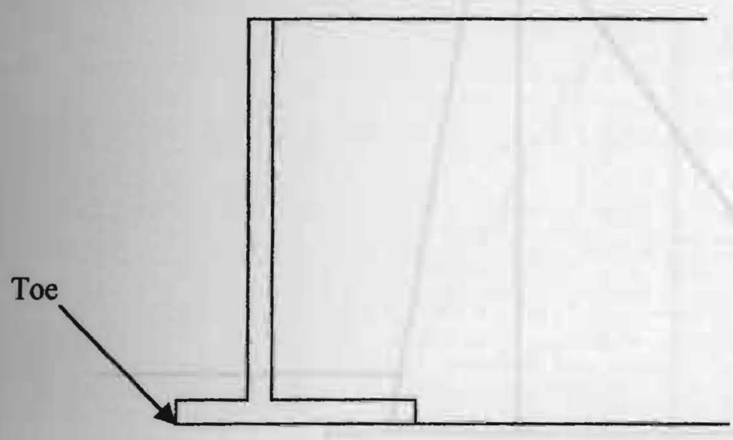
Figure 3.1.1b **Gravity Wall**



3.1.3 Cantilever Walls

Cantilever walls are reinforced concrete vertical walls supported on the slab (base). The wall is usually tied into the slab by reinforcing steel that runs the entire height of the wall. The wall may be keyed into the ground to resist lateral movement. The width of the base is typically 0.4 to 0.7 H. the thickness of the base and stem is typically H/12 to H/10. The projection of the toe beyond the stem is usually B/3. The main advantage of cantilever walls over gravity walls is a considerable savings in concrete. **Figure 3.1.1c** is example of *cantilever wall.*

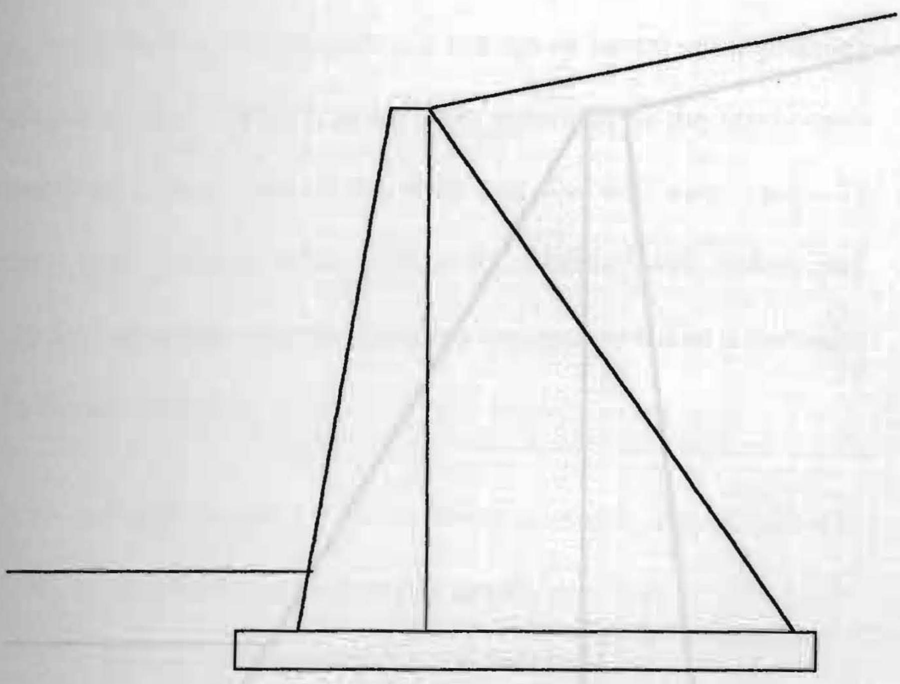
Figure 3.1.1c **Cantilever Wall**



3.1.4 Counterfort Walls

Counterfort walls **(Figure 3.1.1d)** are *cantilever walls* that are equipped with reinforced concrete ribs on the inner (earth) side of the wall. Less reinforcing steel is required for counterfort walls than for cantilever walls, but more forming is necessary. The base width is typically 0.4 to 0.7 H and the slab thickness is B/14 to B/12. The ribs are normally placed 0.3 to 0.6 H apart.

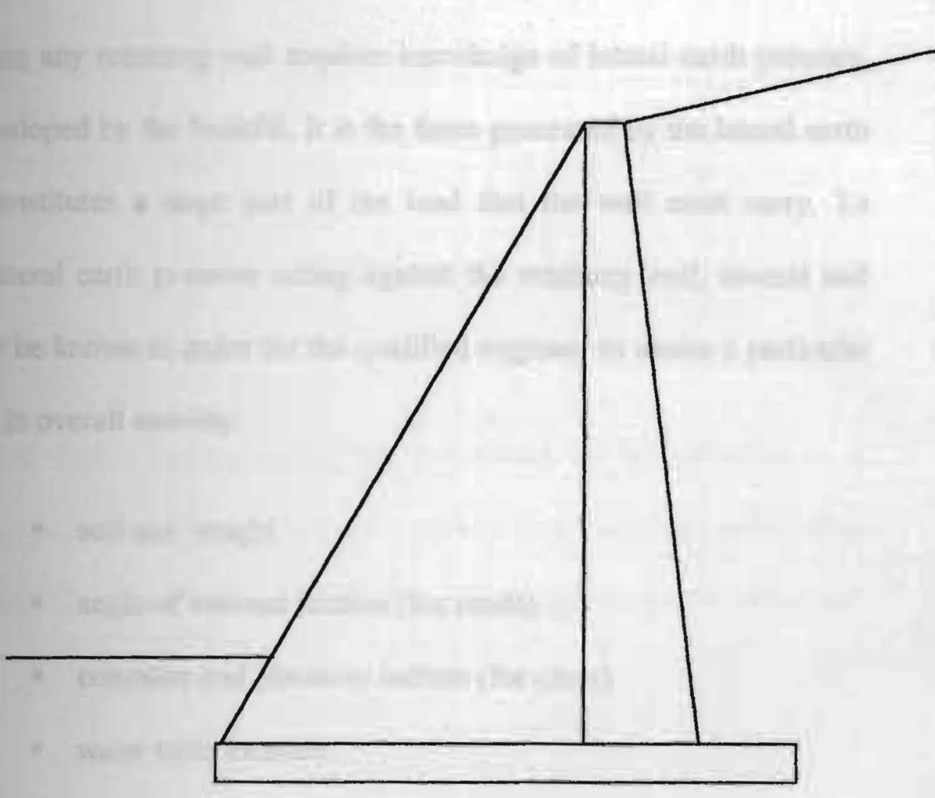
Figure 3.1.1d **Counterfort wall**



3.1.5 Buttressed Walls

Buttressed walls **(Figure 3.1.1e)** are cantilever walls that are equipped with reinforced concrete ribs on the outer side of the wall. The proportions are about the same as for counterfort walls. These types of walls are sometimes used for the support of slopes. A main disadvantage is that the buttresses protrude into the usable space in front of the wall.

Figure 3.1.1e **Buttressed Wall**



3.2 Earth Pressures Applied To Wall

If the wall is fixed in place, such as a foundation wall supported by additional horizontal bracing, then the pressures K_o applied to the wall are at rest. If the wall has moved or in moving away from the backfill, then active pressures K_A are being applied to the wall. If the wall has been or is being forced into the backfill, then passive pressures K_p are being applied to the wall.

3.2.1 Lateral Earth Pressure

Designing any retaining wall requires knowledge of lateral earth pressure, the pressure developed by the backfill. It is the force generated by the lateral earth pressure that constitutes a large part of the load that the wall must carry. To determine the lateral earth pressure acting against the retaining wall, several soil parameters must be known in order for the qualified engineer to assess a particular wall design and its overall stability:

- soil unit weight
- angle of internal friction (for sands)
- cohesion and plasticity indices (for clays)
- water table location.